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Abstract

IRRADIATION BEHAVIOR OF FLUID FUELS

W. R. Grimes (Oak Ridge National Laboratory)
E. G. Bohlmann (Oak Ridge National Laboratory)
L. D. Kirkbride (Los Alamos Scientific Laboratory)
D. H. Gurinsky (Brookhaven National Laboratory)

Three types of fluid fuels have been studied in the United States in the past five years. These include aqueous solutions and slurries, solutions of uranium or plutonium in liquid metals, and solutions of uranium tetrafluoride in molten fluorides.

Operation of Homogeneous Reactor Experiment-2 (uranyl sulfate solution) demonstrated safe operation of a fluid-fuel reactor, maintenance of a highly radioactive system, and recombination of radiolytic H_2 and O_2 by a homogeneous catalyst Cu^{++}. However, power-dependent deposition of uranium on the Zircaloy-2 core vessel was encountered with resultant severe corrosion and melting of the metal. Improvement of the core hydrodynamics apparently obviated the deposition under HRE-2 conditions; it was concluded a suitably designed system would be operable, but fuel and material requirements leave little margin for error.

Operation of LAPRE-II showed the fuel, a solution of uranium oxide in phosphoric acid, to be stable under irradiation and to recombine the H_2 and O_2 effectively without added catalyst; practicable materials of construction have not been demonstrated.

Aqueous oxide slurries have also been explored, but most of the effort in the U. S. was devoted to thoria slurries for blankets. Out-of-pile studies showed

that flocculated thoria suspensions prepared with 1 to 5 μm attrition-resistant particles had practicable engineering properties; however, in-pile experiments showed such particles underwent extensive comminution under reactor (fissioning) conditions. No radiation enhancement of corrosion was observed.

A sodium-cooled reactor (Los Alamos Molten Plutonium Reactor Experiment), whose fuel is a stagnant molten alloy of plutonium and iron, was operated with the tantalum-capsule/fuel interface as hot as 690C. Penetration of the weld regions and some thinning of the capsule walls at the liquid/vapor interface occurred both in- and out-of-pile. A less corrosive plutonium/cobalt/cerium alloy will be used in the near future. About 95% of the fission gases are evolved from the fuel, but a progressive reactivity loss due to growth of gas bubbles on the capsule walls is observed during operation.

The Liquid Metal Fueled Reactor, a graphite-moderated reactor fueled with a circulating, dilute solution of uranium, zirconium and magnesium in bismuth, was stopped short of completion. Testing in a circulating loop under irradiation showed the fuel solution to be stable and suggested no evidence of enhanced corrosion.

The graphite-moderated MSRE will be fueled with a solution of UF_4 in a melt of LiF, BeF_2 and ZrF_4. Graphite, metal and fluoride are completely compatible in pre-irradiation tests. Under irradiation at proposed operating temperatures (650C) very small quantities of CF_4 are formed, but corrosion of the metal remains negligible. The graphite remains unwetted and essentially undamaged. Fluorine is liberated from such fuels by beta and gamma radiation below about 150C, and some of the observed effects are attributable to this phenomenon. Most fission products remain dissolved as fluorides, noble metals may deposit from the melt as metals or carbides, and gases are evolved from the fuel and partially retained by the porous moderator.